AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph beginning at page 1, line 29, and continuing to page 2, line 10, as follows:

A stand-alone GPS receiver can obtain full locking to GPS satellite signals without having any other information about the system except the nominal carrier frequency and the rules by which data carried by the signals are modulated. Such a receiver measures ranging signals transmitted by a number of satellites (normally four). The signals include a so-called Coarse/Acquisition (C/A) code that is unique for each satellite and repeats itself every 1 ms. Superimposed on the C/A code is a navigation data bit stream with a bit period of 20 ms. The navigation data includes parameters that enable[[s]] calculation of the satellite position at the time of transmission as well as parameters describing the offset of the satellite clocks. A stand-alone GPS receiver normally needs to decode the complete navigation data stream before the receiver location can be calculated. This may take quite a long time and requires a certain minimum signal strength. The receiver can determine the boundaries of the C/A code at a much lower signal strength than the one required to decode the navigation messages.

Please amend the paragraph beginning at page 3, line 31, and continuing to page 4, line 4, as follows:

US ~~patent~~ Patent ~~[3]~~6,430,415 describes an approach for dealing with situations where the mobile terminal does not know the GPS network time. The approximate time of a satellite measurement is time stamped. The difference between true GPS network time and this measurement time is treated as an unknown in subsequent computations of the mobile terminal location. This requires one additional satellite measurement, i.e. five satellite measurements instead of the four used in conventional positioning methods.

Please amend the paragraphs beginning at page 4, line 14, and continuing to page 5, line 23, as follows:

A general object of the ~~present invention~~technology described herein is to improve the positioning of mobile terminals capable of receiving satellite signals. A specific object is to provide an error correction mechanism suitable for AGPS. Another object is to provide satellite-based positioning of mobile terminals with correction for errors due to

estimations or reconstructions related to parameters measured at the mobile terminal. Still another object is to achieve satellite-based positioning of mobile terminals with efficient error correction in combination with a reasonable computational complexity.

~~These objects are achieved in accordance with the attached claims.~~

Briefly, the ~~present invention~~technology described herein provides an improved procedure for locating (positioning) a mobile terminal, which receives signals from a plurality of satellites and measures pseudoranges to the satellites. The procedure involves correction for errors in time and/or pseudorange parameters measured at the mobile terminal (or errors in representations of such parameters). The main idea is to use the error correction only when needed, whereby the complexity of the process of calculating the position of the mobile terminal is reduced to a minimum while still achieving a satisfactory precision in the determined location. The location of the mobile terminal is first calculated based on the pseudoranges without error correction or with partial error correction. Thereafter, a quality measure associated with the location calculation is determined and this parameter estimate quality is compared to a predefined quality criterion, preferably based on the residual of a least squares solution for the mobile terminal location. The predefined quality criterion can for example be a predefined threshold value of a suitable quality parameter such as a minimum loss function. In case the predefined quality criterion is fulfilled, no further calculations are needed. Should, on the other hand, the quality of the first calculation be insufficient, the location of the mobile terminal is recalculated with added correction for errors in at least one time/pseudorange parameter measured at the mobile terminal (or a representation/reconstruction of such a parameter) and used for calculating its position.

When calculating (or recalculating) the location of the mobile terminal according to the ~~present invention~~technology described herein, a set of nonlinear equations is defined involving unknown parameters for the UE location and the UE clock bias. If correction for errors in a time parameter is included, there is an additional unknown parameter for the time offset (e.g. defined as the difference between the time of signal transmission from the respective satellites and the network time of the satellite-based positioning system). The nonlinear system of equations is linearized and then solved in a conventional manner, preferably in a weighted least squares sense.

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Please amend the paragraphs beginning at page 6, line 14, and continuing to page 6, line 23, as follows:

The ~~present invention~~technology described herein offers efficient positioning of mobile terminals with enhanced error correction and thus more accurate location calculations. A sophisticated solution is provided with quality checks that makes it possible to perform error correction only when needed. In this way, complex and time demanding computations can often be avoided, improving the overall system performance.

According to other aspects of the invention a mobile terminal, a positioning node and a communication system with means for satellite-based determining of mobile terminal locations are provided.

Please amend the paragraphs beginning at page 6, line 27, and continuing to page 7, line 14, as follows:

Fig. 1 is a schematic view of an example communication system in which the ~~present invention~~technology described herein may be used;

Fig. 2 is a timing diagram illustrating clock relations in an example communication system in which the ~~present invention~~technology described herein may be used;

Fig. 3A and 3B are flow charts of methods for determining the location of a mobile terminal in a wireless communication network according to example embodiments of the ~~present invention~~technology described herein;

Fig. 4 is a flow chart of an iterative calculation procedure for pseudorange outlier correction used in an example embodiment of the ~~present invention~~technology described herein; and

Fig. 5 is a schematic block diagram of a mobile terminal in accordance with an example embodiment of the ~~present invention~~technology described herein.

Please amend the paragraph beginning at page 8, line 7, and continuing to page 8, line 10, as follows:

Fig. 1 is a schematic view of an example communication system in which the ~~present invention~~technology described herein may be used. In this example scenario a basic wireless communication system 110 is used together with the GPS system 130 to provide mobile station assisted AGPS.

Please amend the paragraph beginning at page 13, line 30, and continuing to page 14, line 13, as follows:

The ~~present invention~~technology described herein provides an improved positioning mechanism with correction for errors in time and/or pseudorange parameters measured at the mobile terminal. The main idea is to basically use the error correction only when needed, whereby the complexity of the process of calculating the position of the mobile terminal can be reduced to a minimum while still achieving a satisfactory precision in the determined UE location parameters. For this, the ~~present invention~~technology described herein proposes to first calculate the location of the mobile terminal without error correction or with partial error correction, i.e. without using all parts of the complete error correction procedure. Thereafter, the quality of the results (i.e. of the used parameter estimates) is determined and compared to a predefined quality criterion e.g. a predefined threshold value of a suitable quality parameter. In case the predetermined quality criterion is fulfilled, no further calculations are needed. Should, on the other hand, the quality of the first calculation be insufficient, the location of the mobile terminal is recalculated, this time with added correction for errors in at least one of the parameters (time/pseudorange) measured at the mobile terminal and used for calculating its position.

Please amend the paragraphs beginning at page 14, line 23, and continuing to page 16, line 12, as follows:

When calculating (or recalculating) the location of the mobile terminal according to the ~~present invention~~technology described herein, a nonlinear system of equations is

defined involving unknown parameters for the UE location and the UE clock bias. In case correction for errors in time parameters is included, there is an additional unknown parameter for the transmission time offset. The latter implies that one additional satellite measurement, and thus one additional nonlinear equation, is required unless the dimensions of the determined UE location is to be reduced by one. The nonlinear system of equations is linearized and then solved in a conventional manner, preferably in a weighted least squares sense.

The error correction performed in accordance with the ~~present invention~~technology described herein (provided that the predefined quality criterion is not already fulfilled) can involve either correction for errors in a parameter for time of signal reception, or correction for errors in a pseudorange parameter (truncated or not), or a combination of both. Some preferred embodiments, described more in detail below with reference to Fig. 3A and 3B, use a stepwise solution for error correction where comparisons with two or more predefined quality criteria may be performed at different stages of the process. The positioning is then first performed based on a time of signal reception at the mobile terminal, in case such a parameter is available. If the quality of the result does not meet a first criterion, there is a new calculation which for example may include a transmission time offset estimation, whereby the measured time of signal reception is not needed. The resulting quality is again checked, using a second criterion, and in case of insufficient quality the position is recalculated again, now with correction for pseudorange errors in addition to (or instead of) the transmission time offset estimation.

The ~~present invention~~technology described herein offers efficient positioning of mobile terminals with enhanced error correction and thus more accurate location calculations. When error correction methods are introduced this generally results in more time-demanding and complex calculations requiring more processing power, which is especially problematic in connection with AGPS. The invention recognizes this and provides a sophisticated solution with quality checks by means of which it is possible to perform error correction only when the quality really is bad. In this way, complex and time demanding computations can often be avoided, improving the overall system performance. Moreover, as will be evident in the following, the proposed quality checks enables for a minimum of additional satellite measurements in the error correction. The

proposed solution is very favorable for AGPS which consistently seeks ways of simplifying the positioning of cellular phones and similar devices.

It follows from the above that the ~~present invention~~technology described herein basically involves three different types of location calculations, involving various degrees and kinds of error correction:

I) Location calculation using a measured/reported reception time

II) Location calculation using an estimated transmission time offset

III) Location calculation with pseudorange outlier correction

The proposed procedure may use a subset or all of these calculation mechanisms performed separately or in combination in ways that will be exemplified in following. However, for a complete understanding of the ~~invention~~technology described herein, the principles of each type of calculation will first be described by way of example.

Please amend the paragraph beginning at page 21, line 6, and continuing to page 21, line 13, as follows:

Now, we turn to the situation where the precise measurement time t_u is not available for location calculations. This may be the case for example if, in UE assisted AGPS, the t_u parameter has not been reported by the UE to the network. Alternatively, the UE may have chosen or been instructed not to use/measure t_u, e.g. if the measurement is assumed to be erroneous (have too low accuracy). In such cases, the ~~present invention~~ technology described herein proposes a calculation mechanism which uses redundant measurements for estimating a constant offset τ in the assumed signal transmission times t_{ti}.

Please amend the paragraph beginning at page 23, line 24, and continuing to page 23, line 31, as follows:

In accordance with a particular advantageous embodiment of the ~~invention~~technology described herein, a mechanism for correction of positioning errors due to bad reported/measured pseudoranges is provided. The proposed scheme for detecting outliers is based on a measure of the parameter estimate quality, such as the loss function value V of Eq. (29) or Eq. (20) whichever is relevant. The parameter estimate

quality is checked against a suitable quality criterion (e.g. a threshold for the parameter estimate quality measure) to see if there are any outlier pseudoranges.

Please amend the paragraph beginning at page 24, line 14, and continuing to page 24, line 23, as follows:

The outlier detection and correction in accordance with the ~~present invention~~ technology described herein can for instance involve an iterative calculation procedure, in which the location calculation is repeated n times, n being the number of pseudorange measurements, and where in the kth repetition the kth pseudorange is being omitted from the position calculation. The quality of all n obtained solutions is evaluated and, assuming that the best quality was achieved for the kth repetition and that the resulting quality is deemed to be acceptable, it is concluded that the kth measurement was faulty. The final location returned to the node making the positioning request is determined based on the position calculation with the kth measurement being omitted.

Please amend the paragraph beginning at page 25, line 1, and continuing to page 25, line 15, as follows:

Fig. 3A is a flow chart of a method for determining the location of a mobile terminal in a wireless communication network according to an example embodiment of the ~~present invention~~technology described herein . This example position calculation accounts for both the risk of erroneous reception time t_u and the risk of outlier pseudoranges ρ, preferably in a stepwise procedure. The procedure initially takes two different paths depending on whether the time t_u of reception of the respective satellite signals measured at the mobile terminal is available for use in the location calculations or not. In a network-based scenario (*mobile station assisted AGPS*), this means that the procedure in step S1 asks if t_u has been reported by the mobile terminal to the network or not. In a scenario where the position calculation is performed at the mobile terminal (*mobile station based AGPS*), the reception time t_u is always available for measurements at the mobile terminal. Nevertheless, there may be cases where the mobile terminal chooses not to measure/use t_u and this is handled by step S1.

Please amend the paragraph beginning at page 27, line 1, and continuing to page 27, line 16, as follows:

Moreover, in accordance with particular advantageous embodiments of the ~~invention~~ technology described herein it is proposed to divide the error correction into further substeps, as illustrated by the flow chart of Fig. 3B, which can be seen as an alternative sub-procedure to be inserted between points *A* and *B* in Fig. 3A. Steps S4-1 and S4-1', respectively, correspond directly to steps S4 and S4', respectively (Fig. 3A). However, in case the subsequent quality check (step S4-2 / S4-2') reveals that the quality is insufficient, the location is recalculated (step S4-3 / S4-3') again using the other error correction type, i.e. transmission time offset estimation in case pseudorange outlier correction (with t_u) was used first, and vice versa. In accordance with these embodiments, the combined error correction of step S6 (Fig. 3A) will be used only in case none of the separate mechanisms with correction for errors in t_u or pseudorange outliers is capable of achieving sufficient quality alone. In such cases, there will be a comparison with a third quality criterion, which may equal the second criterion as the illustrated V_{thr2} or be different, followed by a third recalculation provided that the criterion is not fulfilled.

Please amend the paragraph beginning at page 27, line 23, and continuing to page 28, line 18, as follows:

The location calculations in accordance with the technology described herein~~present invention~~ that involve pseudorange outlier correction (step S4, S6 of Fig. 3A and step S4-1, S4-3' of Fig. 4B) can for example comprise an iterative calculation procedure such as the example procedure of Fig. 4. The outlier correction involves *n* cases with computation of the mobile terminal location x_k (k=1, 2,.. , n), n being the number of pseudorange measurements available (step S6-1). The computations of step S6-1 are performed such that in the *k*th case, the *k*th pseudorange measurement is excluded from the position calculation. This position calculation function either uses t_u, e.g. according to Eq. (19), or includes estimation also of the transmission time offset τ, i.e. involves a combination of correction for errors in the measured/reconstructed t_u and ρ, e.g. using Eq. (28). In step S6-2, the parameter estimate quality is determined for the computed location x_k. Step S6-3 asks if there are more pseudorange parameters available. If so, k is increased by one and steps S6-1 and S6-2 are repeated for the next pseudorange. If all available pseudoranges have been used (k=n), the procedure continues with evaluation of the determined parameter estimate qualities (steps S6-4, S6-5, S6-7). A comparatively high quality is hereby interpreted as an indication that the omitted

pseudorange is an outlier. If an outlier pseudorange is detected, this pseudorange is removed from the set of measurements and is not included in the determination of the final terminal location. In the example with loss function thresholds, the outcome of the *n* computations is *n* loss function values V_k. If the smallest loss function value $minV$ among these *n* loss function values is smaller than a threshold V_{thr}, it is concluded that an outlier has been successfully detected and removed (S6-5, S6-6). Otherwise it is concluded that no outlier could be removed, whereby the location computed with all available pseudoranges will typically be used (S6-7, S6-8). The procedure is terminated and the obtained location is preferably reported along with an uncertainty area.

Please amend the paragraphs beginning at page 28, line 28, and continuing to page 29, line 22, as follows:

As mentioned in the background section, ~~[3]~~ US Patent 6,430,415 describes an approach for dealing with situations where the mobile terminal does not know the GPS network time by using the difference between true GPS network time and approximate time a satellite measurement as an additional unknown in computations of the mobile terminal location. This requires one additional satellite measurement and results in demanding calculations with regard to processing time and power. In accordance with US Patent 6,430,415~~[3]~~, this kind of extended processing would always be used, imposing heavy demands on the positioning functionality in the mobile terminal and/or cellular network. The technology described herein~~present invention~~ recognizes that a more appropriate positioning functionality can be achieved by introducing quality checks in the location calculations. The proposed solution distinguishes between different error correction needs and applies different degrees of error correction/parameter estimation depending on the situation. Therefore, a minimum of additional complexity is introduced in the calculations while obtaining an sufficient precision in the positioning. The quality checks of the technology described herein~~present invention~~ also makes it possible to improve the positioning further by including functionality correcting for outliers in the pseudorange measurements.

Although implementing the technology described herein~~invention~~ in accordance with Fig. 3A (and Fig. 3B) is very favorable, the skilled person recognizes that still other flow

sequences are possible as well. The respective steps with outlier correction and transmission time offset estimation can for example be performed in parallel. Furthermore, the quality criteria in step S3 and S5 (and S4-2, S4-2') as well as in the S6 procedure may be equal ($V_{thr1} = V_{thr2}$) or different ($V_{thr1} \neq V_{thr2}$), fixed or varying. In the example with loss functions, it will generally be appropriate to use different quality criteria at least for calculations associated with different degrees of freedom.

Please amend the paragraph beginning at page 30, line 17, and continuing to page 30, line 32, as follows:

Fig. 5 is a schematic block diagram illustrating an exemplary hardware implementation of a mobile terminal in accordance with the technology described herein~~present invention~~. The mobile terminal 500 ~~consists of a an~~comprises a GPS RF front end 510, a positioning module/processor 520, a cellular communication module 530 (with a cellular RF module 532 and a cellular baseband processor 534), as well as antennas 512, 536 for communication with the cellular network and the GPS system, respectively. The cellular communication module 530 receives assistance data from the cellular network. The assistance data could ~~consist of~~comprise ephemeris and clock corrections for visible satellites, an approximate UE location and an approximate GPS system time. Alternatively, the assistance data could contain explicit assistance intended only for assisting the correlation processing. The assistance data is in both cases sent to the positioning module 520. The communication module 530 also provides the GPS RF front end 510 and the positioning module 520 with a clock reference. The RF front end module 510 is controlled by the positioning module 520.

Please amend the paragraph beginning at page 32, line 12, and continuing to page 32, line 17, as follows:

The predetermined quality criterion used in accordance with the technology described herein~~present invention~~ to determine whether further error correction should be applied, has mainly been exemplified as a threshold value of the minimum loss function. Other embodiments may use other quality criteria than the minimum loss function. The quality criterion is preferably related to the residual of a least squares solution providing

the mobile terminal location, e.g. based on the residual variance/covariance, but other criteria can be used. Basically, any suitable measure of the match between predicted and measured parameters (e.g. time or pseudorange parameters) affecting the location calculations can be used.

Please amend the paragraph beginning at page 32, line 27, and continuing to page 32, line 31, as follows:

Although the ~~invention~~ technology described herein has been described with reference to specific illustrated embodiments, it should be emphasized that it also covers equivalents to the disclosed features, as well as modifications and variants obvious to a man skilled in the art. Thus, the scope of the invention is only limited by the enclosed claims.

Please amend the paragraph beginning at page 33, line 32, as follows:

~~[3] US Patent 6,430,415 B1, Qualcomm Inc.~~